CRANIOMETRY AND CEPHALOMETRY IN RELATION TO IDIOCY AND IMBECILITY.

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In a paper read before the New York Neurological Society in 1888 (*New York Medical Record*, June 23, 1888) on "Some of the Principles of Craniometry," I gave in brief form a description of the instruments needed, the methods employed, and the facts to be gained by a study of the conformation of the head and skull in criminals and the insane. As in idiocy, and imbecility in particular, we meet with remarkable deviations from the normal type of head and skull, I feel that more attention should be paid to a study of craniometry in connection with this class of cases than has hitherto been the case. And with this object in view I seek to embody here all the facts that will serve as a guide to a study of the kind under consideration.

A score or more of distinguished anthropologists of the present century have been trying to discover racial distinction in human skulls; but the fact is that there are not so many characteristics of

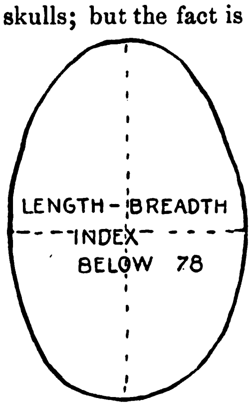
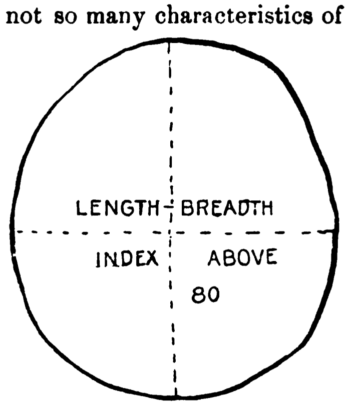


FIG. 1.



race in the cranium as in other parts of the body, and accordingly there are still wide differences of opinion as regards a scientific craniological classification. Races have been mingling so many thousands of years that cranial dissimilarities are the rule among them, even in tribes, and to some extent in families. These diversities of form have been designated as dolichocephalic, mesocephalic, and brachycephalic, words which merely convey an idea of the relation of the length to the breadth of the skull when viewed from above. The antero-posterior is to the biparietal diameter as 100 is to x, is the formula for determining this "cephalic index." All length-breadth indices below 78 are considered dolichocephalic; 78 to 80, mesocephalic; and above 80, brachycephalic. We may assume that the physiological limits of this index are 70 to 90. This is based upon thousands of measurements of skulls by various investigators. Any excess or diminution of these figures must hence be regarded as pathological. (Fig. 1.)

I would merely make passing mention of the fact that, according to latest classifications (Huxley and others), most Europeans and most of the people east of a line drawn from Lapland to Siam are brachycephalic; that negroes, Australians, English, Irish, and Scandinavians are dolichocephalic, and the Hollanders, mesocephalic.

But while one skull may be narrower or broader than another, there is compensation in other diameters. The dolichocephalic has a greater vertical diameter, for instance, than the brachycephalic skull.

Besides these characteristics something must be said regarding the physiological asymmetry of the skull. The fact that the arms

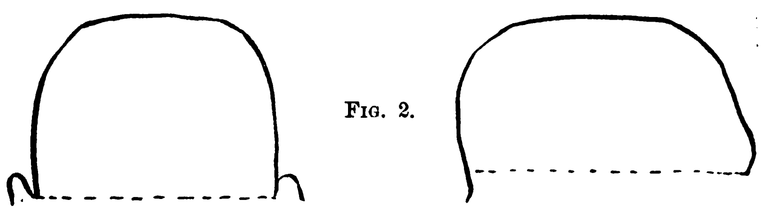


FIG. 2.

and hands are not symmetrical on the two sides of the body, either in size or in function; that the legs and feet are not symmetrical; that the left cerebral hemisphere is larger and more complicated than the right, would naturally lead us to anticipate some slight asymmetry of the two sides of the skull, and the facts of observation support us in the statement that asymmetry is the rule, and perfect symmetry the exception. More than a thousand post-mortem examinations, the examination of several hundred heads, and an inspection of some collections of skulls, such as that of Blumenbach, where I have particularly noted this point, together with the testimony of others, justify me in this assumption.

Asymmetry sometimes reaches extraordinary proportions, often with quite a normal state of brain function, often with marked psychopathic changes. Outside of purely physiological asymmetry we have that depending upon defective development and disease. One of the first of nature's constructive principles in fashioning the skull is the struggle of its contents for volume. Hence, as long ago pointed out by Virchow, premature synostosis of any cranial suture will lead to compensatory deformity. So, too, will arrest of development in any center of ossification, or a unilateral aplasia or hyperplasia of the skull bones, or of the contents of the skull.

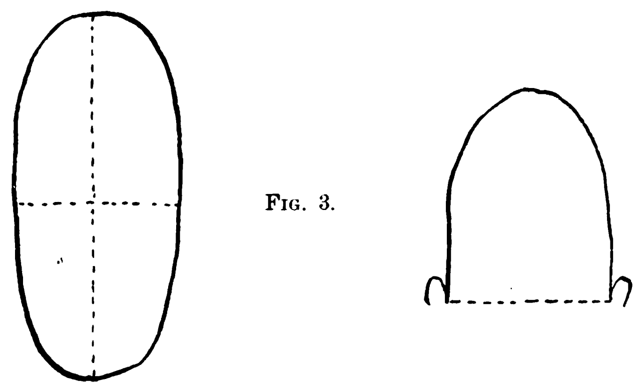


FIG. 3.

Aside from the deformities of the head, which are congenital in character, the diseases which most commonly produce cephalic deformation in early life are rachitis and hydrocephalus; in later life, tumors, exostoses, ostitis, etc.; while at all periods of life the shape of the skull is menaced by injuries, from a forceps delivery to a falling brick. The following are some of the commoner designations of well-known cranial deformities:

Chæmocephalus is flat-headedness. In this there is flatness at the top of the head. This is also called *platicephalus.* (Fig. 2.)

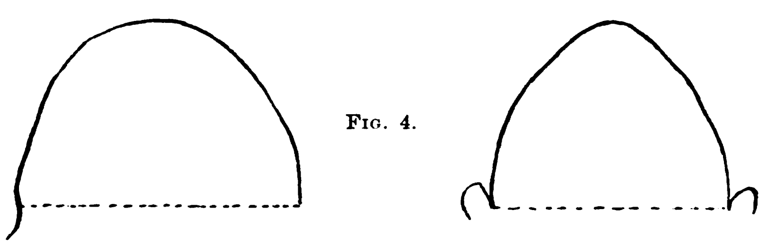


FIG. 4.

Leptocephalus. Early synostosis of the frontal and sphenoid produces leptocephalus or narrow-headedness. (Fig. 3.)

Macrocephalus is a large head usually due to hydrocephalus.

Microcephalus is a small head due either to aplasia of the brain or premature synostosis of the sutures.

Oxycephalus, or steeple-shaped skull, is due to synostosis of the parietal with the occipital and temporal bones, with compensatory development in the region of the bregma. Another name for this is *acrocephalus*. (Fig. 4.)

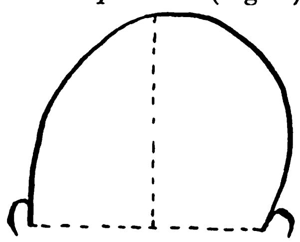


FIG. 5.

Plagiocephalus, or oblique deformity of the head, is due to unilateral synostosis of the frontal with one of the parietal bones. (Fig. 5.)

Scaphocephalus is probably caused either by too early union of the sagittal suture or by the development of both parietal bones from one center. The top of the head is keel-shaped. (Fig. 6.)

Trigonocephalus. Premature union of the frontal suture, resulting in very narrow forehead and great width behind, giving rise to the term trigonocephalus. (Fig. 7.)

It is to be regretted that we have no studies of the psychical histories of tribes accustomed to producing artificial malformation of their heads during development. There are eight or ten species of artificial deformity which have been practiced from time immemorial among the lower races of mankind, and are still in vogue among certain Polynesian and American tribes. The disfiguration is accomplished by means of bandages, boards, or masses of clay fastened upon the infantile skull to produce the prevailing fashionable shape. Many of these skulls are to be seen in the famous collections at Paris, London, and Goettingen.

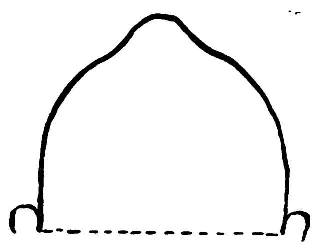


FIG. 6.

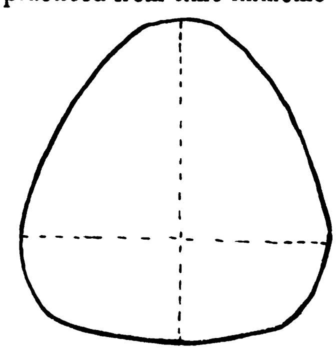


FIG. 7.

It may be affirmed that every segment of the skull represents some particular part of the brain lying beneath it. This may be assumed without proclaiming one's self a proselyte of Gall.

It is certainly true that single convolutions have no very marked influence upon the external configuration of the cranium; but they do, however, strongly impress the inner table of the skull, as will be seen upon examination. The indentations upon the inner table are most distinct on the orbital plate of the frontal, the squamous portion of the temporal, and the upper part of the occipital bone. The orbital surface of the orbital plate of the frontal is perfectly smooth. The outer table of the occipital presents no ridges correlated to the convolutional imprints within, but, on the contrary, has ridges for muscular attachment. The external surface of the squamous portion of the temporal bone is, indeed, modified by the size of the convolutions of the temporo-sphenoidal lobe, but on the head this portion of the skull is obscured by the temporalis. Yet although single convolutions do not impress themselves to such an extent upon the outer surface of the skull as to be recognized, this is not altogether the case with groups of convolutions. Groups of convolutions do modify the shape of the skull, do possess visible representation upon its outer surface.

The great recent advance in cerebral localization paves the way to a newer and more scientific, though more limited, phrenology. Thus the parietal bosses correspond chiefly to the sensory, somewhat to the motor, cortical areas. The dimensions of the forehead have a direct relation to the frontal lobes, the higher intellectual substrata. The left temple has been shown by Benedikt, in one case, to be depressed in congenital aphasia. The parieto-occipital portion of the skull is doubtless modified by the countless sight-memories stored up beneath it. I have, myself, noted in large numbers of cases of infantile spastic hemiplegia an alteration in the shape of the skull on the side opposite to the paralysis. (Some of the Principles of Craniometry, loc. cit., Cranial Measurements in Twenty Cases of Infantile Cerebral Hemiplegia.—*New York Medical Journal*, April 6, 1889.)

The two systems of measurement — the craniometrical and cephalometrical — differ but slightly from each other, the former, of course, being the more exact, since every portion of the naked skull is attainable. Both systems, if perfect, require such measurements to be taken as will serve at any time to reconstruct the skull. Geometry and trigonometry are pressed into use. Certain definite points are selected from the arcs and radii, as shown in some of the diagrams. It will be seen that the longitudinal, vertical, and horizontal sections of the normal skull all exhibit a certain and definite number of curves. In fact, its whole surface may be considered as composed of an aggregation of small cycloid surfaces, developed and joined together according to fixed biomechanical laws, just as a fruit is evolved on biomechanical principles, with its definite number of seeds and concentric disposition of substance. The object of these notes not being to present a formidable treatise on the triangulation of the skull, but to introduce a few practical ideas, and furnish an incentive for more and better work than has hitherto been done in this country upon this subject, I pass over the long series of craniometrical measurements, and also the thirty-eight cephalometrical formulæ recommended to thorough students by Benedikt, to select those which are absolutely necessary in order to form a just idea of the capacity and symmetry of any head — measurements which ought to be taken in every asylum for idiots or insane upon every patient admitted, and in every prison upon every criminal. Even the asylums of Italy surpass us in this respect. At San Servolo, in Venice, which I visited some years ago, fourteen cephalometrical measurements are taken upon every patient at the time of admission. Figures of this kind become in time of immense value.

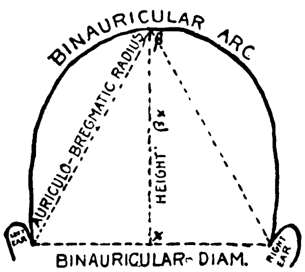


FIG. 8.

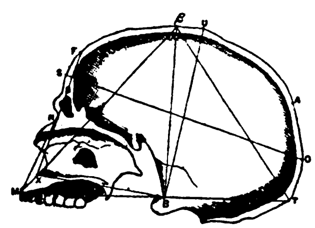


FIG. 9.

I would recommend the eleven following measurements: (Figs. 8 and 9) 1, The circumference; 2, the naso-occipital arc (N to T); 3, the naso-bregmatic arc (N to β); 4, the bregmato-lambdoid arc (β to A); 5, the binauricular arc; 6, the antero-posterior diameter (S to O); 7, the greatest transverse diameter (length-breadth index); 8, the binauricular diameter; 9, the two auriculo-bregmatic radii; 10, the facial length; 11, the empirical greatest height (β to B).

In addition to acquiring these mathematical data, cephaloscopic drawings are invaluable as exhibiting deformity clearly to the eye. Hence, the horizontal circumference, naso-occipital curve, and binauricular curve should be taken with a strip of lead, or, what is better, with the instrument devised by Luys (on the principle of the hatter's conformateurs), and the curves projected on paper.

We will now consider each of these eleven points in detail:

1. The circumference of the skull averages 52 centimeters in men, 2 centimeters less in women, with a physiological variation from 48.5 to 57.4. This measurement is taken horizontally around the glabella and the point just above the external occipital protuberance known as the maximum occipital point, from its giving the greatest antero-posterior diameter (Fig. 9, S to O). The scalp and hair superadd about 3 centimeters; hence, in cephalometry about 6 per cent should be deducted to obtain the measure of the skull. (Six per cent should also be deducted in measurements Nos. 2 and 5.)

An effort has been made by Welcker and others to determine the cubic capacity of the cranium through the relations of some of its diameters or its circumference. But it has been found that the cubic contents vary in different skulls, even when the circumferences are equal. It is probable, however, that by the acquisition of long series of cranial diameters and volumes, we will in time arrive at some standard for approximating the quantity of brain in any head. A very rough empirical estimate is that where the circumference of the skull is 50 centimeters its volume will be about 1,350 cubic centimeters.

2. The naso-occipital arc is measured from the root of the nose to the lowest part of the external occipital protuberance (N to T). The average is 32 centimeters in men, one less in women, with a physiological variation between 28 and 38.

3. The naso-bregmatic, or frontal arc, taken from the root of the nose to the bregma (N to β), averages on the skull about 12.5 centimeters in men, 12 in women, with a physiological variation between 10.9 and 14.9.

4. The bregmato-lambdoid, or parietal arc, which is the measurement of the length of the sagittal suture, and hence the extent of the parietal bones, averages on the skull 12.5 centimeters in men, and 6 millimeters less in women, with a physiological variation between 9.1 and 14.4 (β to A). The bregma and lambda are easily found on the head after some education of the fingers.

5. The binauricular arc is measured vertically over the top of the

skull, following Broca's vertical line, between the two auditory meatuses. We select at the meatus either a point on the anterior rim between the middle and posterior roots of the zygomatic process, easily felt on the head just behind the maxillary articulation, or a point on the posterior superior rim corresponding to a small depression, both of which are fixed points, and differ but slightly in elevation. The average is about 32 centimeters on the skull in men, one less in women, with a physiological variation between 28.4 and 35.

6. The greatest antero-posterior diameter is taken from the glabella, or middle of the forehead, to the maximal occipital point (S to O). It averages 17.7 cm. on the skull of men, 5 mm. less in women, with a physiological variation between 16.5 and 19.

7. The greatest transverse diameter is sometimes between the tubera parietalia, sometimes between the upper portions of the temporal bones. It averages 14.6 cm. in men and 14 in women, with a physiological variation between 13 and 16.5. As before mentioned, the length-breadth index is obtained from these two diameters, Nos. 6 and 7.

8. The binauricular diameter is taken between either of the points described, on the rims of the auditory meatuses. It averages 12.4 cm. in men, 5 mm. less in women, and the physiological variation is between 10.9 and 13.9. In measuring the head, the scalp averages 5 mm. in thickness; hence, in the larger diameters (Nos. 6 and 7) 1 cm. must be deducted to get the figures for the skull, while in shorter measurements (such as Nos. 8 and 9) it is sufficient to substract 7 mm.

9. The auriculo-bregmatic radius of each side is taken from the usual point at the meatus to the bregma. By calculation from these radii and the binauricular diameter, we are enabled to ascertain the distance of the bregma from a point in the median plane, half-way between the two meatuses; this distance averages in the normal skull 11.7 cm., with a physiological variation between 10 and 12.65 (Fig. 8).

10. The facial length is measured from the nasal root to the lowest median point of the inferior maxilla. It averages 12.37, with a physiological variation between 10.5 and 14.4. Including as it does the teeth, infants and the aged are debarred from this measurement Dolichocephalic heads have, as a rule, narrow, and brachycephalic, broad faces. Something should here be said concerning prognathism, of which there are several forms. The best method of deter-

mining it is to measure the angle made by a line drawn from the nasal root to the junction of the inferior nasal spine and alveolar process (Fig. 9, N X) with a vertical line dropped from the nasal root to Broca's horizontal. It is found that every normal skull exhibits this subnasal prognathism, but there is a wide variation in degree. Extraordinary prognathism, orthognathism, and opisthognathism, meaning extreme projection, straightness, or inclination backward of the subnasal line, are pathological.

11. The empirical greatest height of the head is an approximate measurement of the distance between the basion and vertex of the skull (B to β, or U). A line from the external occipital protuberance to the lowest median point of the superior maxilla, just above the incisors (T to M), passes almost directly through the basion. Hence, in cephalometry, by taking this diameter and the radii from each extremity to the bregma, we have a triangle (M β T) whose height (B β) is easily ascertained. The height averages 13.3 cm. in men, 12.3 in women, and the physiological variation is from 11.5 to 15.

The only instruments necessary for obtaining the data just described are a pair of calipers, the tape line, and a strip of sheet-lead two feet long by half or three-quarters of an inch wide. Benedikt's calipers (manufactured by Wolters in Vienna), which are here exhibited, are to be recommended for their exactness (Fig. 10), and also those that I have had made for my own use. (Fig. 11).

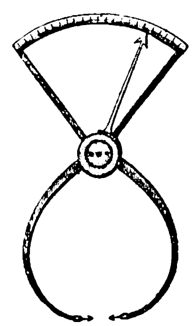


FIG. 10.

In craniometry proper, still other apparatus is required, viz., one for volumetric estimates, with water in a thin rubber bag, and a cathetometric armamentarium, consisting of a craniofixator, cranioepigraph, telescopic leveling apparatus, and an instrument for projection, by means of which every arc and radius and every portion of the bones and sutures may be exactly studied, measured, and drawn. With this instrument Benedikt makes some one hundred and twenty measurements of every skull. By its use the relations of normal and pathological skulls, and the relations of comparative craniology may be defined with scientific precision.

The arc from the lambda to the external occipital protuberance is worthy of study, particularly in cases of congenital or early acquired blindness, now that we know the cunei to be the principal visual centers; and the arcs of the temporal bones also demand investigation as regards their relation to similar conditions of deafness.

Excessive prognathism is found among criminals, in microcephali, and in cases of hemi- and paraplegia spastica infantilis. Skulls known as crania progenæa have considerable pathological significance. In these the lower teeth project beyond the upper, and the inferior maxillary angle is obtuse, due, probably, to aplasia of the upper, or hyperplasia of the lower, maxilla.

The demonstration of the empirical greatest height is often quite valuable as an index of degenerative and neuropathic types.

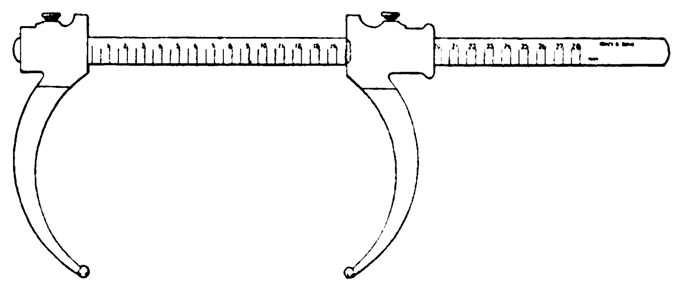


FIG. 11.

The following are some general points which should be considered in the examination of these cases:

A skull below the normal type in volume belongs to an abnormal individual.

Under-typical measurements of the head should always lead us to entertain the suspicion of defective cerebration.

Abnormal smallness of any part of the skull permits the conclusion that the part of the brain in its neighborhood is imperfectly developed.

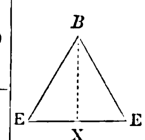
Excessive development of the head has a double signification. It is always pathological, but may mean abnormality of brain or successful compensation. Wormian bones are also doubly significant. They either represent a pathological process or a successful effort of nature in repair.

Hemiplegia spastica infantilis, epilepsy, and intellectual or ethic weakness often exhibit unilateral aplasia of the skull.

The skull is representative of the brain only during the years of its development, and it must be remembered that psychopathic deterioration often has its inception subsequent to the completion of the process, when no impression can be made upon its bony walls.

In order to render the series of normal craniometrical and cephalometrical measurements above described readily accessible, I have condensed the whole in the form of a table, as follows:

TABLE OF CRANIOMETRICAL MEASUREMENTS.

	Average in adult in centimeters.		Physiological variation.	REMARKS.
	Males.	Females.		
1. Circumference.............	52	50	48.5—57.4	Roughly approximated the volume is to the cicrumference as 1350 ccm. is to 50 cm.
2. Volume...	1500	1300	1201—1751	
3. Naso-occipital arc.....	32	31	28—38	In figure *n* to *t*.
4. Naso-bregmatic arc.........	12.5	12	10.9—14.9	*n* to *B*.
5. Bregmato-lambdoid arc....	12.5	11.9	9.1—14.4	*B* to *a*.
6. Binauricular arc	32	31	28.4—35	
7. Antero-posterior diameter..	17.7	17.2	16.5—19	*s* to *o*.
8. Greatest transverse diameter	14.6	14	13—16.5	The formula for the length-breadth index is Length : Breadth :: 100 : x. An index below 78 is dolicocephalic; 78 to 80, mesocephalic; above 80, brachycephalic.
9. Length-breadth index......	82.2	83.8	76.1—87	
10. Binauricular diameter	12.4	11.9	10.9—13.9	 The height *BX* of the triangle E*B*E formed by the auriculo-bregmatic radii and the binauricular diameter, averages 11.17 with a variation from 10 to 12.65
11. Auriculo-bregmatic radii...				
12. Facial length....	12.37		10.5—14.4	From root of nose, *n*, to lowest part of chin.
13. Empirical greatest height .	13.3	12.3	11.5—15	The empirical greatest height, *bB*, is obtained by measuring the sides of the triangle *mBt*.

These measurements are those of the adult human skull. As the hair and scalp superadd about 3 cm., about 6 per cent should be deducted in the head measurements Nos. 1, 3, and 6 to obtain those of the skull. In taking the diameters Nos. 7 and 8, deduct 1 centimeter (the scalp averaging 5 mm. in thickness), and from the shorter radii, such as Nos. 10 and 11, subtract but 7 mm.

For purposes of comparison of the above skull measurements in normal adults I have collected a number of head measurements of idiots and imbeciles, which are here placed in tabular form. The first tables consist of the measurements in eleven adult men and eight adult women, all imbeciles, with infantile cerebral hemiplegia and, except in two cases, epilepsy:

HEAD MEASUREMENTS IN ELEVEN ADULT MALE PARALYTIC IMBECILES.

	NORMAL HEAD.			MALE IMBECILES.											Men's average.
	Average in adults, in centimeters.		Physiological variation.												
	Males.	Females		I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	
Circumference	55	53	51.5-60.4	55.3	53.5	54.0	54.0	53.0	51.0	54.0	53.0	54.5	54.5	51.0	53 7
Volume	1500	1300	1201-1751	1508	1460	1472	1472	1455	1390	1472	1455	1486	1486	1472	1466
Naso-occipital arc	35.0	34.0	31.0-41.0	36.5	35.0	34.0	34.0	35.0	32.0	35.0	34.5	37 5	34.0	33.0	34.5
Naso-bregmatic arc	12.5	12.0	10.9-14.9	12.0	13.0	12.0	11.5	12.5	12.5	13.5	13.0	13.0	13.0	13.0	12.6
Bregmato-lambdoid arc	12 5	11 9	9.1-14.4	12.0	13.0	13.0	12.5	13.0	10.0	10.5	11.0	12.0	15.0	13.0	12.2
Binauricular arc	35.0	34.0	31.4-38.0	35.5	35.0	32.0	33.0	35.0	35.0	33.0	33.5	34.5	36 0	35.0	34.3
Antero-posterior diameter	18.7	18 2	17 5-20.0	19.4	18.1	18.9	18.3	18.0	17.3	18.5	18.1	18.9	18.0	17.5	18.2
Greatest transverse diameter	15.6	15.5	14.0-17.5	14.4	14.0	14.3	14.0	15.2	13.9	14.5	13.8	14.5	15.5	15.0	14.4
Length-breadth index	82.2	83.8	76.1-87.0	74.2	77.3	76.0	76.5	84.4	80.3	78.3	76.2	76.7	86.1	85 7	79.2
Binauricular diameter	13.0	12.1	11.6-14.6	11.5	12 3	12.4	11 5	13.0	11.4	12.0	10.8	12 2	12.1	12.8	12 0
Height, *Bx*	12.2	....	10 5-13.1	13.5	12.5	12.0	12.0	12.4	12.8	12.0	12.3	1205	13 0	13.1	12.5
Facial length	12.37	....	10 5-14.4	12.0	12.0	13 0	11.6	12.0	12.1	12.5	12 2	12.2	11.4	13.0	12.1
Empirical greatest height	13.8	12 8	12.0-15.5	15.2	13 2	13.0	12.3	14.0	12.6	13.5	13.4	14.5	14.4	13.0	13.6

HEAD MEASUREMENTS IN EIGHT ADULT FEMALE PARALYTIC IMBECILES.

	FEMALE IMBECILES.								Women's average.
	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	
Circumference	53 5	48.5	51.5	53.0	52.0	54.0	51.5	54.5	52.3
Volume	1310	1128	1261	1298	1274	1323	1261	1335	1281
Naso-occipital arc	32.5	30.0	32.0	32.0	31.0	34.0	34.0	31.5	32.1
Naso-bregmatic arc	11.5	10.0	11.0	10.5	11.0	12.5	12.0	12 0	11.3
Bregmato-lambdoid arc	14.0	12.5	12.0	12.0	12.0	12.0	11.0	12.0	12.1
Binauricular arc	30.0	31.0	31.5	35.0	31.5	33.5	33.5	35.0	32.6
Antero-posterior diameter	18.6	16.8	18.0	17.5	17.9	18.7	17.9	17.9	17.9
Greatest transverse diameter	14.0	13.5	14.0	14.7	14.0	14.4	13.9	15.7	14.2
Length-breadth index	75.2	80.3	77.7	84.0	79.8	77.0	77.6	87.7	79.9
Binauricular diameter	11.5	11 0	11.3	11.8	12.0	11.5	11.0	11.5	11.4
Height, *Bx*	11.6	11.2	11.0	12.3	11.5	11.6	12.0	12.2	11.6
Facial length	12.0	10.8	9.9	11.6	11.5	10.2	11.1	11.4	11.0
Empirical greatest height	12.8	11.5	12.3	12.3	11.3	12.5	12.7	12.7	12.2

With regard to the above measurements there are a number of valuable deductions to be made.

The average circumference is below the average of normal male and female heads. The same applies to the empirical determination of the volume.

The naso-occipital arc is diminished in 6 men and 6 women, while 1 woman is below the physiological variation. The averages of the 11 men and 8 women are below the normal averages of the two sexes.

The naso-bregmatic arc is below the normal averages in 3 men and 5 women, but the average of the 11 men is 1 mm. above the normal and that of the 8 women 7 mm. below. Two women are so low as to be outside of the physiological variation.

The bregmato-lambdoid arc is under the normal in 5 men. The average of the 11 men is below, and that of the 8 women 4 mm. above the normal sexual averages. It is this arc which Benedikt claims is diminished in cases of ordinary epilepsy, but this probably does not apply to the meta-hemiplegic variety exhibited in seventeen of these cases.

The binauricular arc is diminished in 5 men and 6 women, the total averages of each sex being also below the normal standards. Two of the women are under the extreme of physiological variation.

The antero-posterior diameter is less than the normal averages in 8 men and 6 women, and below the physiological extreme in 1 man and 1 woman. The total averages of the 11 men and 8 women are below the normal sexual standards.

The greatest transverse diameter is below the normal average in all the men and all but one of the women, showing the tendency toward leptocephalus, or narrow-headedness, in this form of hemiplegia pointed out by Benedikt. Under the physiological variation are 4 men and 2 women, or more than 30 per cent.

As regards the relation of length to breadth, the length-breadth, or cephalic index, 8 men and 6 women are below the average. Six men and 4 women are dolichocephalic, 1 man and 2 women mesaticephalic, and 4 men and 3 women brachycephalic. Two men and 1 woman exhibit dolichocephaly outside of the physiological variation, while one woman presents pathological brachycephaly. Taking the averages of the cephalic indices of the nineteen adults, they are all below the average brachycephalic condition and are mesaticephalic.

The binauricular diameter is under the normal standards in all the men and all the women. This being but another transverse diameter, corroborates the result of the measurements of the greatest transverse diameter, viz., the inclination to leptocephalus before mentioned. In 4 men and 6 women, or more than 50 per cent, this tendency is so marked that the binauricular diameters are actually outside of the physiological extremes.

The height bregma-x is diminished in 3 men and pathologically increased in 1. Unfortunately there is no normal female average as yet determined with which to compare the women.

The facial length is below the average in 9 men. We have as yet no statistics as to the normal average in women.

The empirical greatest height is under normal standards in 7 men and 7 women, and the total averages diminished in all 19. Two women present pathological minima.

In many of the cases unusual prognathism is apparent in variable degree, and in some are deformities of the palate and jaws.

Now, if each case be examined singly with reference to normal cephalometrical standards, we find that pathological conditions stand out more prominently than in the aggregate analysis.

Case No. 1, which in many of its measurements surpasses the normal average, and which is the greatest of the twenty cases in circumference and volume, exhibits pathological variation in the cephalic index (74.2), binauricular diameter (11.5), and height (β x 13.5).

Case No. 3 presents pathological divergence in the cephalic index (76).

Case No. 4 has a binauricular diameter outside of the physiological limits (11.5).

Case No. 6 exhibits pathological variation in the antero-posterior diameter (17.3), greatest transverse diameter (13.9), and binauricular diameter (11.4).

Case No. 8 shows an abnormal divergence from the physiological limits in the greatest transverse diameter (13.8) and in the binauricular diameter (10.8).

Case No. 10 presents pathological excess in the bregmato-lambdoid arc.

Case No. 12 is pathological in its binauricular arc (30), cephalic index (75.2), and binauricular diameter (11.5).

Case No. 13 exhibits pathological variation from normal standards in circumference (48.5), volume (11.28), naso-occipital arc (30), naso-bregmatic arc (10), binauricular arc (31), antero-posterior diameter (16.8), greatest transverse diameter (13.5), binauricular diameter (11), and empirical greatest height (11.5); in fact, most of the measurements.

Case No. 14 is pathological in its binauricular diameter (11.3) and facial length (9.9).

Case No. 15 presents an abnormal minimum in the naso-bregmatic arc (10.5).

Case No. 16 is pathological in its empirical greatest height (11.3).

Case No. 17 shows morbid deficiency in the binauricular diameter (11.5) and facial length (10.2).

Case No. 18 exhibits pathological variation in the greatest transverse diameter (13.9) and binauricular diameter (11).

Case No. 19 is pathologically excessive in the cephalic index (87.7 and deficient in the binauricular diameter (11.5).

From this it will be seen that all of the cases taken in the aggregate have skulls which fall below the normal average in nearly every measurement, while in fourteen of the nineteen cases the variation is outside of the physiological limits in some of the arcs or diameters.

Besides the mathematical data, three cephaloscopic delineations were taken in each case. The naso-occipital arcs are drawn in such a manner as to give an almost composite view of this arc in each sex, and the slight deviations that exist are perceptible at a glance. Their only value is merely for comparison with normal standards, from which they differ chiefly in length, and hence they are not reproduced here.

The horizontal circumference was taken through the points which give the antero-posterior diameter, viz., around the glabella and the maximum occipital point about an inch above the occipital protuberance. Although this is somewhat below the arcs which would be described around the mid-region of the motor areas, and which would naturally better characterize the pathological change of cranial outline, yet in every one of these drawings a variation is observable between the right and left semicircles, in some slight, and in others very marked, the diminution being always on the side of the lesion, and therefore opposite to the paralyzed half of the body. (For these illustrations see Cranial Measurements, etc., *loc. cit.*) The fact of the existence of epilepsy in cases of hemiplegia is probably significant of an irritative and not a destructive lesion of the cortex; and hence it is natural to infer that the unilateral differences in the brain and skull would be greater in such hemiplegias without epilepsy.

The binauricular arcs were taken, as usual, between the anterior rims of the auditory meatuses, and by their greater contiguity to the motor areas, present rather more distinctly the unilateral differences than do the right and left horizontal semicircles. Each binauricular arc exhibits a diminished quadrant on the side of the lesion. The pathological variations in the quadrants are often more marked in these cases when the arc is described behind the auditory meatuses from one mastoid process to the other, for thus the chief portions of the Rolandic areas are traversed; but the arcs taken are a sufficient demonstration of the facts stated.

In conclusion I would make the following summary of the facts obtained by a study of these nineteen heads of paralytic imbeciles:

In all of these cases of hemiplegia spastica infantilis the skull is more or less diminished in size on the side opposite the paralysis.

There is a pronounced tendency to diminution in all dimensions and capacity. This is so marked in the transverse diameters as to bring these heads under the class of leptocephalus.

While all of the heads are below the normal averages, more than 73 per cent are actually below the lowest limit of physiological variation in some of their dimensions.

The value of the above tables, then, from an anthropological point of view, lies in their determination of the intimate relationship existing between portions of brain and adjacent cranial areas; from a psychological point of view, in their proving or assisting to prove the interdependence of small-sized heads and mild degrees of feeble-mindedness, congenital or acquired in infancy.

I append here a table of measurements of heads of idiots in thirteen selected cases of marked deformities of various kinds. A careful examination of the figures, and comparison with the normal measurements in the same table, will show the wide variations often observed.

In the matter of circumference it will be seen that there are pathological excesses in ten of the cases, that is, figures outside of the physiological variation (51.5 to 60.4).

As regards the rough approximation of volume only two seem to be outside of the physiological limits (1201 — 1751 ccm.); but it is clear that, while this method of estimating the volume is fairly correct for heads which are not greatly deformed, it is far too uncertain for such malformed heads as are here given. Take, for instance, the first case of hydrocephalus in the list with a circumference of 63.5, but with an enormously excessive height (19.2). Estimating the volume by the formula for the circumference, 50 : 1350 :: 63.5 : X, we have 1714 ccm. as a result. Were we, however, to contrast in a similar formula the normal relation of height to volume, we have a far different result. Thus, normal height 12 is to normal volume 1300 as 19.2 is to X, and the result is, the pathological case is the enormous volume of 2080, which is, in this case at least, probably much nearer the actual capacity of the hydrocephalic skull than the figure given in the table.

MEASUREMENTS OF HEADS OF IDIOTS WITH STRIKING DEFORMITIES OF THE SKULL.

CASE.	Sex.	Age.	Circumference.	Approximate volume.	Naso-occipital arc.	Naso-bregmatic arc.	Bregmato-lambdoid arc.	Binauricular arc.	Antero-posterior diameter.	Greatest transverse diameter.	Length-breadth index.	Binauricular diameter.	Auriculo-bregmatic radii.	Facial length.	Height *Bx.*	Empirical greatest height.
Normal male........	M	adlt	55	1500	35	12 5	12.5	35	18.7	15.6	82.2	13.1	....	12.3	12 2	13.8
Normal female......	F	adlt	53	1300	34	12	11.9	34	18.2	15	83.8	12.6	....	...	..	12 8
Microcephalus.......	M	41	49.5	1339	32	11	14	26	16.5	13	82.4	12	12	12.8	10.3	11.9
Microcephalus.......	M	13	37	899	20	9	9	21	12	9.5	79.1	9.5	9.7	9	8.4	8.6
Microcephalus hemiplegic..............	M	26	48.5	1309	29	10	13	32	15.4	13.1	85	12.4	12.7	12.1	11.2	12.2
Microcephalus hemiplegic	M	6	47	1151	31	9.7	8.6	29	16.3	13.1	80.3	10.1	....	9	11.1	....
Microcephalus paraplegic..............	M	25	46.5	1255	29	10	11	29	15.9	11.3	71	10.5	11.5	10.7	10.2	11.1
Leptocephalus (dolicocephalus)	M	26	57.5	1552	39	16	15	35	20.5	13 2	64.3	10.3	13.6	11.7	12.7	14.6
Oxycephalus	M	19	54	1458	35	15	13	37	18.2	13.8	75.8	11	15	12	14	14.5
Trigonocephalus (brachycephalus)..	M	12	49	1323	31	11	11	32	16	14.5	90.6	12	12.5	10.3	11	11.4
Trigonocephalus (brachycephalus)...	F	25	50 5	1363	32.5	12	13.5	34.5	15.5	15	96.7	11.8	13	10	11 7	12.4
Hydrocephalus.......	F	19	63.5	1714	47	16.5	19	50	19 5	18.5	94.8	12	20	11.2	19.2	17.7
Hydrocephalus (cured).....	F	35	62	1674	42	17	17	43	21.5	17	79	11	16.2	12.5	15.2	15.9
Hydrocephalus.......	M	9	61	1647	41	15.5	16	43	21	17.6	83.8	12.2	15.5	9.2	14.2	14.7
Hydrocephalus.......	M	9	57.5	1552	39	14	16	40 5	20	15.5	77.5	10.8	15.6	8.7	14.7	13.5

The great deficiencies and excesses in the naso-occipital and binauricular arcs are very noteworthy.

The length-breadth indices are interesting, too, for the enormous brachycephalus in three cases, and the extreme dolicocephaly in one.

The excesses in the height βx and the empirical greatest height are striking in several of the cases.